Offshore Wind O&M Challenges

Credit: Siemens

2011 Wind Turbine Condition Monitoring Workshop

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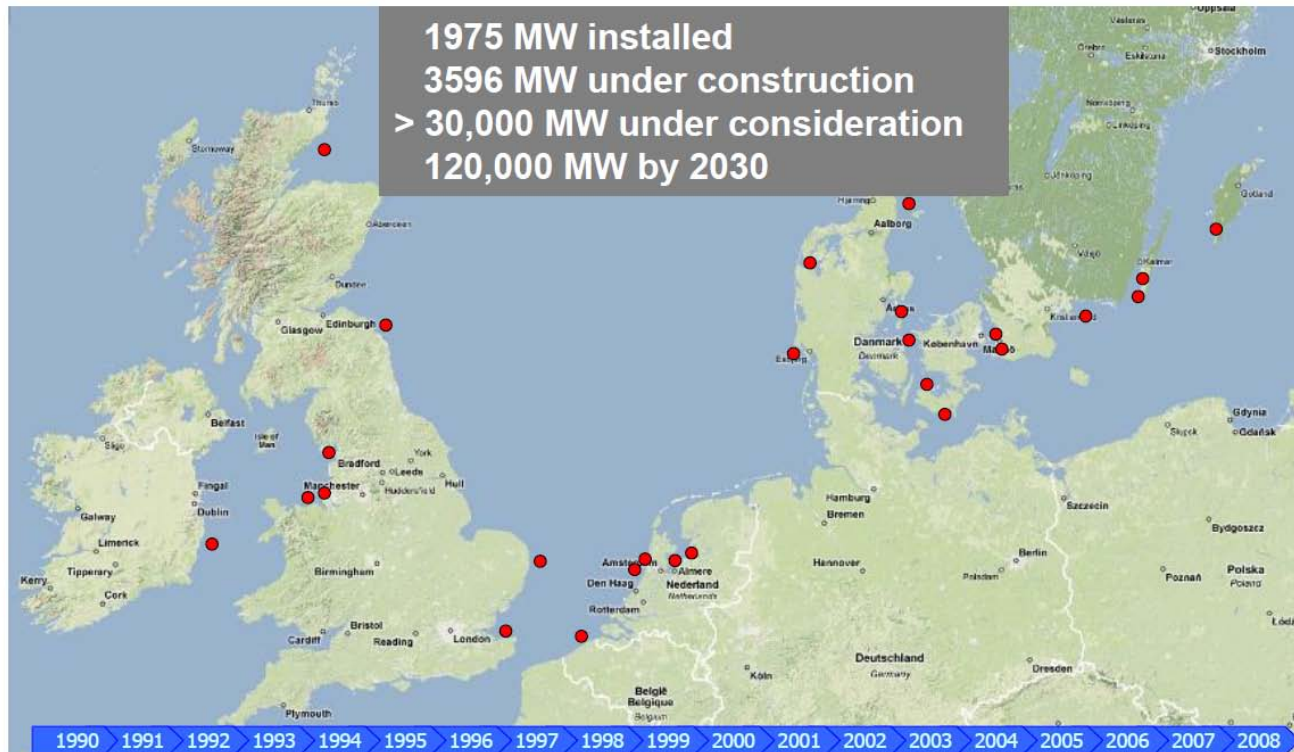Senior Engineer
Offshore Wind and
Ocean Power Systems**

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Overview

- – Offshore Wind in Europe
- – Offshore Wind in the United States
- – Current Technology
- – Technology Trends
- – Offshore O&M Challenges
- – Opportunities

Offshore Wind in Europe

1975 MW installed
3596 MW under construction
> 30,000 MW under consideration
120,000 MW by 2030

Source: TUDelft Offshore Engineering / ECN

34

China: 135MW installed; 2GW authorized
United States: 2.4 GW proposed

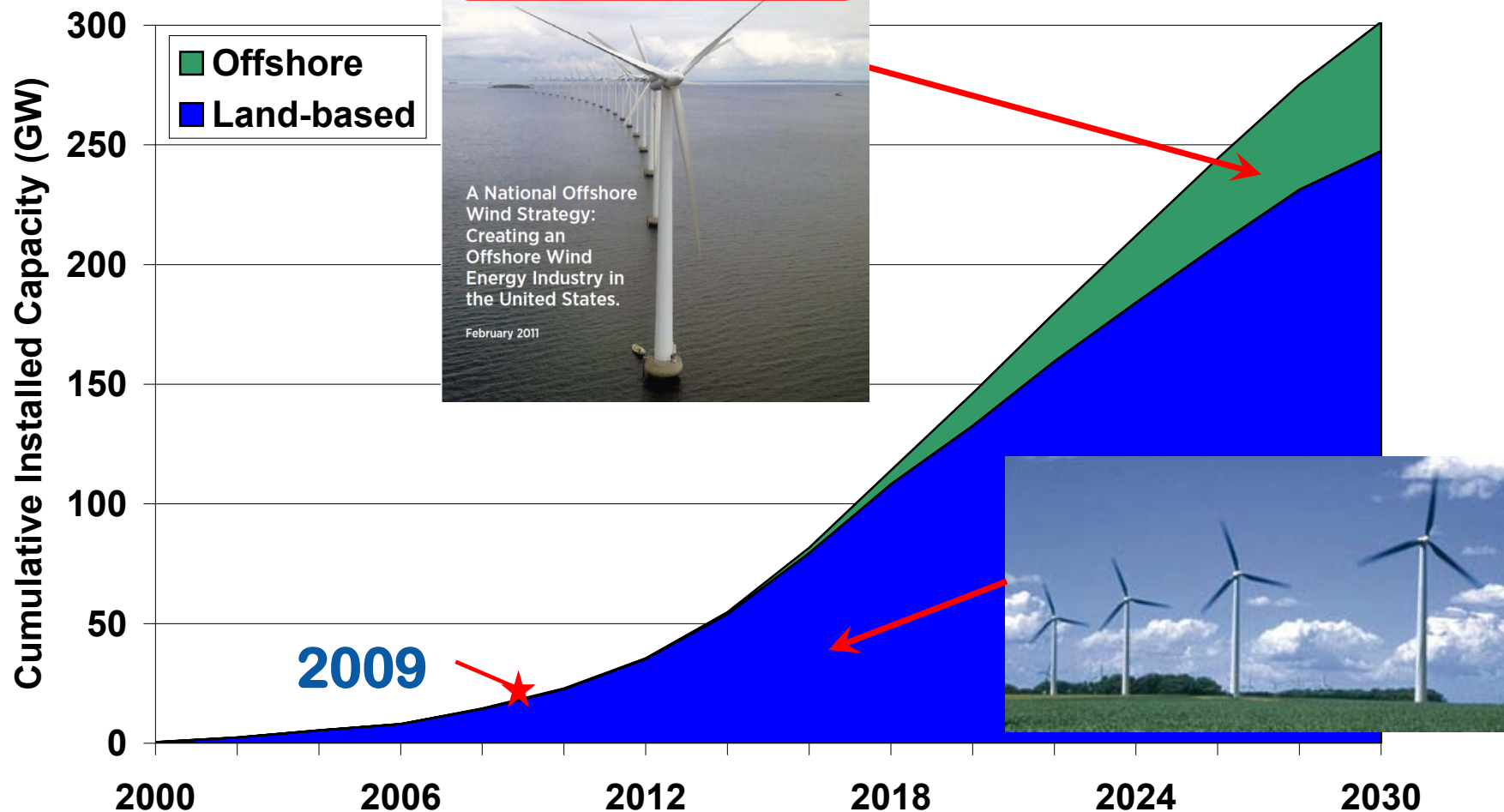# Offshore Wind in the United States

Offshore Wind in the United States

Current Technology

Surface Ice

Deep Water

Deep Water

Tropical Storms
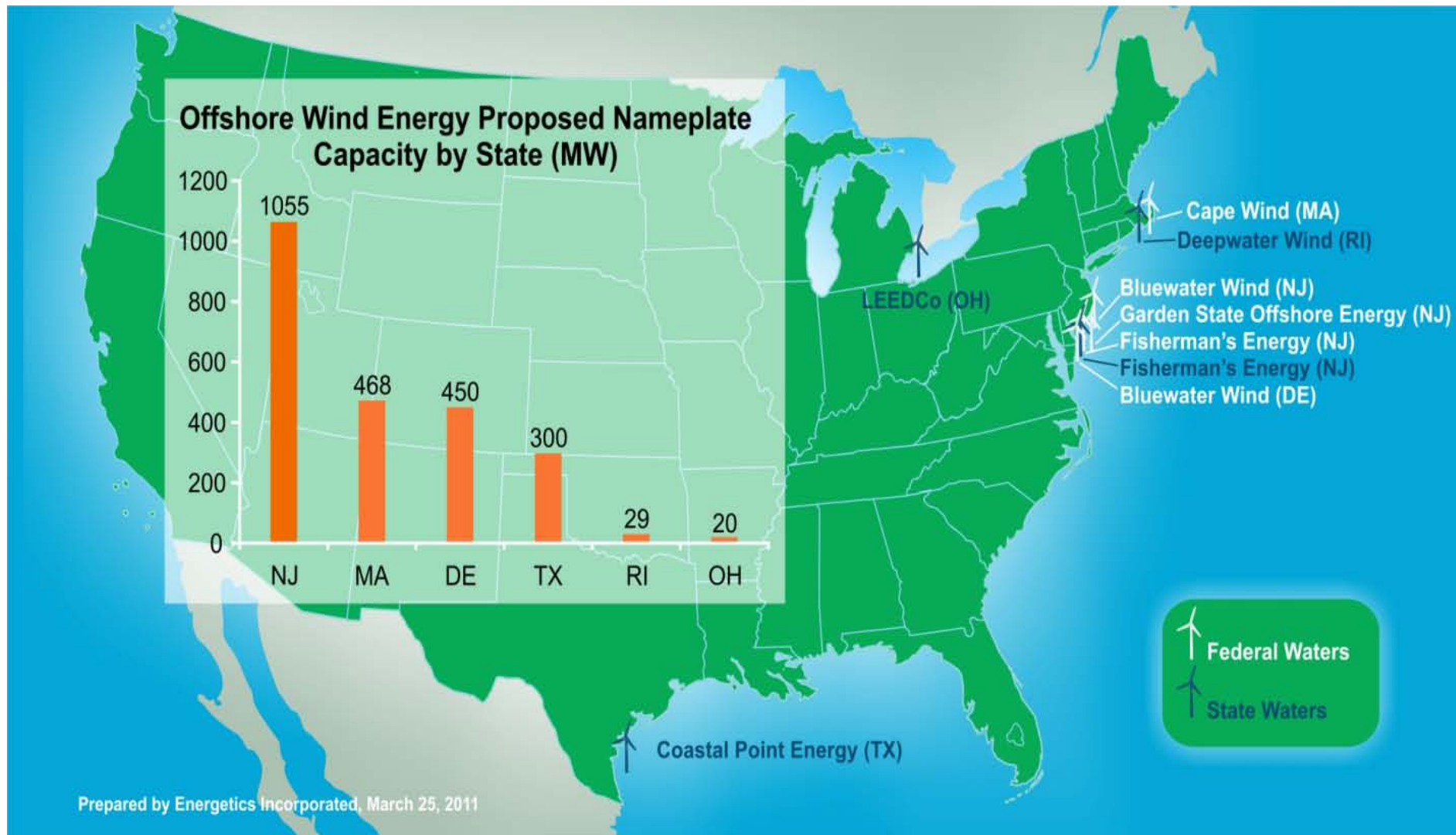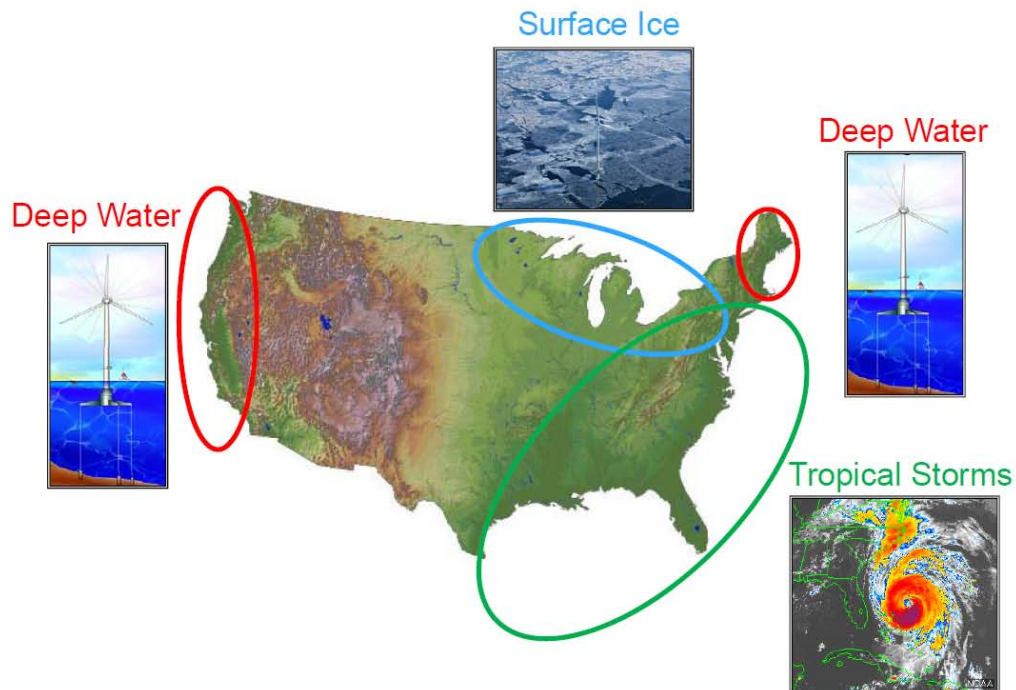
New sensors and condition based monitoring equipment will be needed to adapt to these new environments.

Technology Challenges

– Corrosion Protection
– Nacelle pressurization
– Personnel Access, shelter, and safety
– Wind/Wave Structural Design
– Hurricanes
– Ice Loading
– Grids and submarine electrical infrastructure
– Condition monitoring and predictive maintenance
– Inspection
– Decommissioning
– Environmental impacts

Current Technology
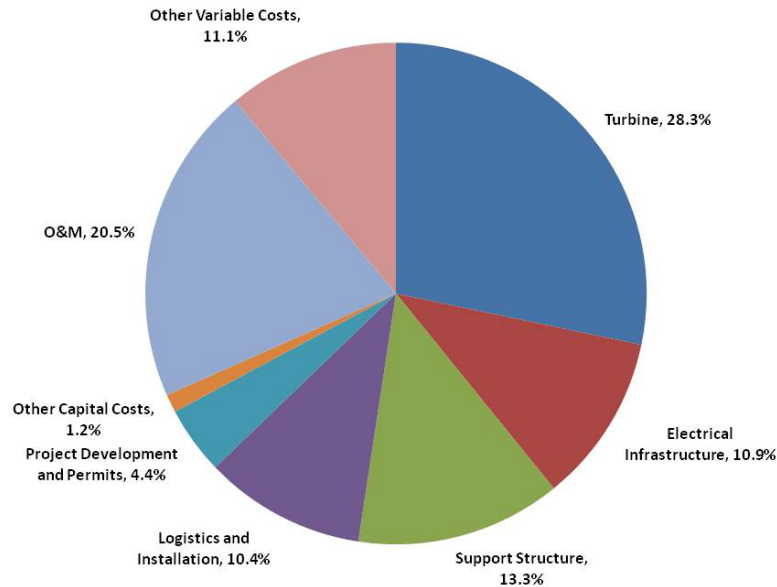
Estimated life cycle cost breakdown for a baseline offshore wind project

Source	O&M Cost (2010$/MWh)
Ernst & Young (2009)	$50
KPMG (2010)	$27 - $48
ECN (Lako, 2010)	$40 - $66
EWEA (Krohn, et al, 2009)	$21
IEA (Salvadores and Keppler 2010)	$11 - $54
Cape Wind (MDPU 2010)	$30 to $50
Average	$39

Offshore wind O&M cost estimates

- Operations and maintenance costs vary significantly by project:
  - Depth
  - Distance to shore
  - Prevailing sea and weather conditions (UKERC 2010).
- Offshore O&M costs are estimated to be twice as much as onshore
  - ~20.5% of life cycle costs of an offshore wind project
  - Reported values range from $11 - $66/MWh
  - Driven by frequent minor repairs or faults that are unknown

Current Technology

- Fixed bottom shallow water 0-30m depth
- 2 – 5 MW upwind rotor configurations
- 70+ meter tower height on monopoles and gravity bases
- Existing oil and gas experience is essential
- **Reliability problems have discouraged early boom in development**.
- Costs are 2X land-based due to higher than expected cost and **uncertainty with O&M**, logistics, and installation.

Current Technology

Offshore Wind farm Maintenance Egmond aan Zee

Offshore demonstration project supported by Dutch government
– Selection of site
– Issue of building permits
– Investment subsidy
– Production subsidy

Built and operated by NoordzeeWind
– 36 Vestas 3 MW V90 wind turbines
– 1 met mast, 116 m high
– Hub height 70 m, rotor diameter 90 m
– Monopiles with scour protection
– Water depth 20 m
– 3 x 34 kV cables to the shore
– 34/150 kV substation on shore
– Renewable electricity for
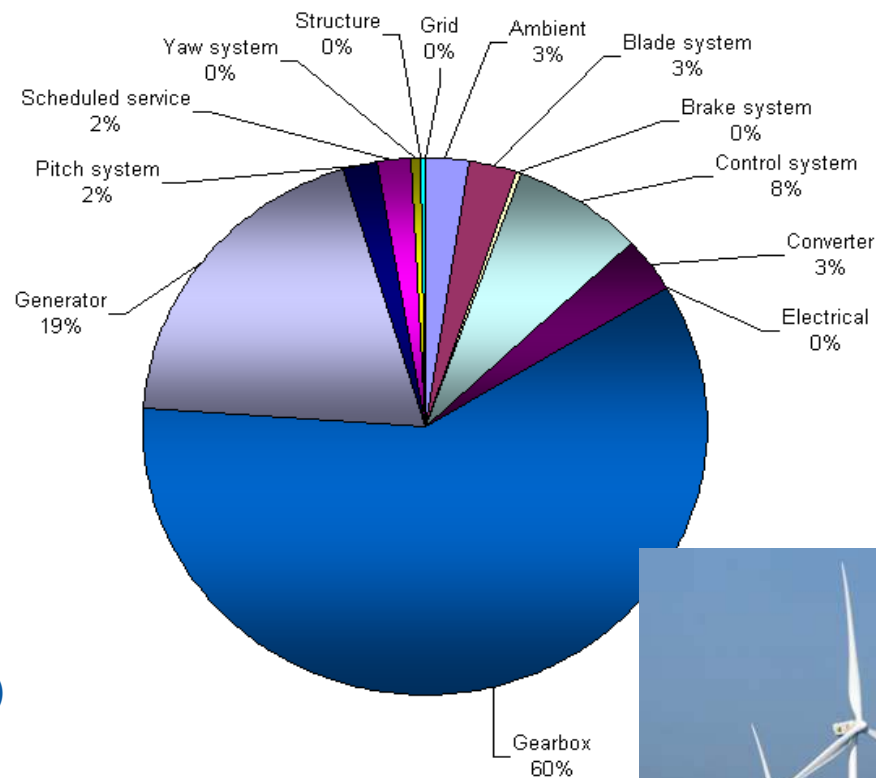 +/- 100.000 house holds (~ 330 GWh)
– Design life 20 years

Percent Lost MWh

Ref: Operations Report 2008, NoordzeeWind, Doc No. OWEZ_R_000_20090807
Operations 2008.pdf, websites: www.noordzeewind.nl

Structure 0%
Grid 0%
Ambient 3%
Blade system 3%
Yaw system 0%
Brake system 0%
Scheduled service 2%
Control system 8%
Pitch system 2%
Converter 3%
Generator 19%
Electrical 0%
Gearbox 60%

Slide Credits:

**Jaap 't Hooft
SenterNovem**

**Henk Kouwenhoven
NoordzeeWind**

EOW 2009 Stockholm
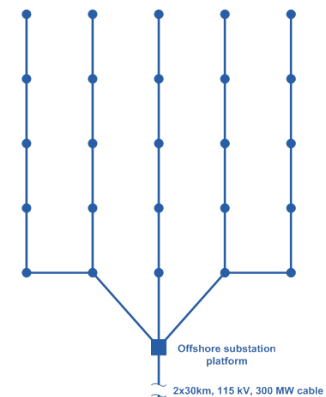
Technology Trends

- Turbine Scaling
  - Larger rotors, taller towers, higher nameplate capacity, primarily enabled by advanced controls (UpWind 2011).
  - Component and machine economies of scale. Fewer trips from port to installation site.
  - Fewer foundations and maintenance trips per unit of installed capacity.
  - Reduced production, installation, and O&M costs.
  - Downtime on larger scale turbines will have larger impact on AEP
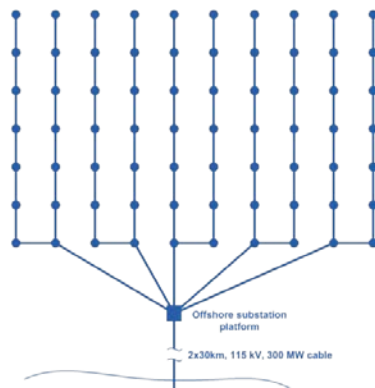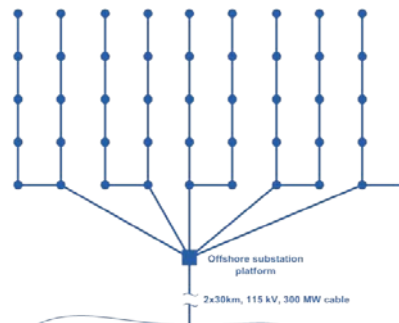
3.6 MW Turbines   **5 MW Turbines**   **10 MW Turbines**

Offshore machines will have a higher value proposition for health monitoring technology.

Offshore Maintenance Challenges
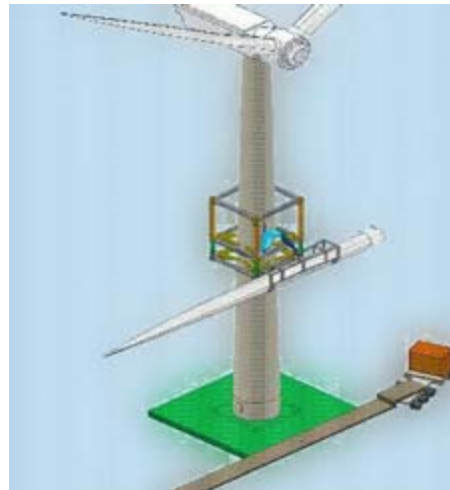
Credit: ABB

Credit: GE Energy

Lower availability in offshore projects has been an issue– 80-95% as compared to 95-98% onshore

– Vessel deployment cost and logistics

– Accessibility

  • Eliminate need for specialized vessels

  • Weather Windows

  • Safe personnel access

– Reliability

  • Turbine designs for reduced maintenance

Offshore Maintenance Challenges

Courtesy: www.scottish-enterprise.com/stn-feb07-3

Vessel Deployment Costs and Logistics

– Day rates for vessels are very expensive

– Vessels are scarce and may not be available when needed.

– To minimize costs maintenance actions should limit use

– Turbine designs should incorporate strategies to avoid large vessel dependence.

Offshore Maintenance Challenges

Accessibility

- 30-50 % down time due to poor weather
- Varies from site to site and year to year
- Accessibility is dependent on weather conditions
- Sea state is a driving factor
- Stepping off a boat to a landing point is only safe in calm waters
- Weather windows can be widened with better access and construction methods
  - smaller boats
  - temporary bridges
- Improve forecasting integrated into maintenance strategy

Offshore Maintenance Challenges

Reliability

– Reliability is central to offshore economic viability.

– Reliability must be improved at the design stage.

– How to improve reliability:

  – All systems and subsystems should be specified. Understand failure modes and risk of failure

  – Certification

  – Comprehensive testing at full systems level and subcomponent level

  – Redundancy only where appropriate

  – What should the target be?

Opportunities

Health Monitoring

– Improved preventative and corrective maintenance schemes are critical for economic viability

- reduce the number of unscheduled visits

- can avoid the cost of site visits through improved CBM.

– Intelligent integrated control systems that are self diagnostic

- fault accommodating control can help mitigate control system failures with strategies that compensate for sensor and actuator faults

- increased robustness that allows maintenance to be delayed until a scheduled visit to minimize access frequency

Example of Alarm Severity Responses

Severity	Type	Planning of inspection
6	Danger	Immediate Response
5	Alert	One week response
4	Alert	Inspect on next scheduled visit
3	Alert	scheduled visit
2	Good	No action
1	System	Check on next visit